Arnold Schwarzenegger
Governor

CENTRALIZED DAIRY DIGESTER WITH POWER GENERATION

PIER FINAL PROJECT REPORT

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Preface

The California Energy Commission's Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program conducts public interest research, development, and demonstration (RD&D) projects to benefit California.

The PIER Program strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

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- Renewable Energy Technologies
- Transportation

Centralized Dairy Digester with Power Generation is the final report for the SMUD ReGen Program project (Contract Number 500-00-034) conducted by Sustainable Conservation. The information from this project contributes to PIER's Renewable Energy Technologies Program.

For more information about the PIER Program, please visit the Energy Commission's website at www.energy.ca.gov/pier or contact the Energy Commission at 916-654-5164.

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Abstract

This project report summarizes the work from several project deliverables relating to a comprehensive feasibility study of a community digester and/or power generation project. The project evaluated the viability of such a system for Sacramento County dairies and looked at the larger California context and potential for centralized facilities including a biogas digester and/or engine generator. The project specifically investigated potential business structures, evaluated permitting issues, interconnection barriers, and financial factors, and synthesized "rules of thumb" for digester viability based on dairy size and amount of manure available. The project team also created a roadmap for dairies that are interested in a community digester project.

Keywords: Dairy, digester, biogas, methane, anaerobic digester, combined heat and power

Executive Summary

Introduction

This project assessed the viability of a community digester and/or centralized generator system focusing on Sacramento County dairies. A central premise of the study has been that there are economies of scale to a centralized facility both in terms of the capital and operating investment as well as the cost of regulatory compliance. The possibility for a more cost-effective and efficient digester and/or power generation system installation increases when neighboring dairies collaborate with one another. Collaboration could help spur more digesters that serve multiple environmental and public policy benefit purposes.

Purpose

This project analyzed the barriers and benefits of a centralized dairy digester, or genset, and produced a business plan for building such a facility in Elk Grove, California. It was also intended that the outcomes could serve as a model not just for Sacramento County but for dairies throughout California and perhaps elsewhere.

Project Objectives

The institutional barriers to utility interconnection, environmental permitting, sales power and farmer collaboration have proven particularly vexing; strategies to overcome them are therefore critical. The project evaluated the barriers to interconnection, wheeling power, environmental permitting, marketing power to the utility, and forming farmer collaborations capable of managing a common business venture.

Technical and economic feasibility studies of a community digester for co-located dairies in Elk Grove were performed and compared to feasibility studies of individual digester projects. The study assessed the cost and benefits of two cooperative scenarios, comparing a centralized digester and generation facility with one where only the generation facility was centralized. The study also looked at clusters of six neighboring dairies with herds ranging from 340 to 1,050 dairy cows in Sacramento County to determine the most attractive location for a group of dairies.

Finally, the project developed a business plan to finance the construction of the preferred digester system. Most dairies in Sacramento County are typically under 500 cows in size, and there are more challenges to developing a workable model because they lack economies of scale. The project explored the regulatory and market framework necessary for project success and geographic limitations with regard to proximity and size. The project team also developed a "roadmap" intended to serve as a guide for other community digester projects to follow, including a plan for expediting utility interconnection and managing shared responsibility, risk, liability, and maintenance.

Project Outcomes

There are several noteworthy findings from the investigation. A central conclusion was a community digester project is feasible at an identified location for two adjacent dairies that have a combined number of approximately 2,000 cows. The broader implication from the analysis also suggests that 1,000 is about the minimum size needed, assuming around 6 cents per kilowatts/hour in power sales, among other assumptions. It was also found that pumping manure to a central digester with an accompanying electricity generating facility was the preferred option over trucking manure to a central digester or individual digesters piping biogas to a common generator facility, because of the significantly higher cost of two digester enclosures compared to the smaller cost differential of two versus one engine-generator. In either case, trucking manure or piping gas more than four to five miles poses financial challenges to project viability. However, these results are highly site-specific, and a different option or set of options may be preferable at other dairy sites.

It is estimated that over the 10-year period of the proforma analysis, the community digester project would provide approximately $1.3 million in financial advantage (net value after debt) mainly divided between electricity and fiber sales but also in avoided electricity purchase. There are additional monetary benefits from reductions in greenhouse gas emissions, but no calculations were included in this assessment. The simple payback period, assuming total project cost of $2.4 million and an initial grant of $500,000, is approximately 7.8 years. This is a viable, if less than ideal, project for a dairy owner to undertake. It compares to two separate digester projects of smaller size (for example, two 1,000 cow dairies) built and permitted separately at a project cost of $1.3 million for each digester, each offset by a $287,500 grant, resulting in a simple payback for each project of 8.8 years. This is somewhat less attractive but still feasible. However, new requirements adopted in 2007 by the Regional Water Quality Control Board and the San Joaquin Valley Air Pollution Control District now make the centralized digester much more attractive because the high cost of pollution control technology can be assigned to the larger 2,000-cow facility. A facility of half that size was estimated by Andgar (a project team member) to cost about 70 percent of the larger facility.

It was also an important conclusion that a limited liability company was the preferred organizational structure for a collaborative effort for the sites and in the context analyzed. However, other models may emerge that are preferable depending on individual factors.

Recommendations

Most of the barriers identified to community systems were found to be surmountable, although concerted and well-thought-out plans are needed to expedite regulatory approvals and interconnection to the power grid. Some of these institutional barriers will require a much larger effort and strategy on a statewide scale if community or individual dairy biogas facilities are to be attractive to a larger population of dairymen.

Benefits to California

According to a California Biomass Collaborative report, if manure digesters captured all available dairy manure and used the methane-rich biogas to generate electricity, up to 350 megawatts (MW) of new renewable energy production would occur.[1] However, the report states that less than half of this is technically feasible—somewhere around 150 MW.

Digesters need to be looked at from a comprehensive perspective. They are not only energy generators and collectors of potent greenhouse gases, but they are also a means to reduce odors, improve water quality, potentially improve air quality, and provide additional financial security for dairymen. An economic and organizational model that encourages their adoption is needed.

1. California Biomass Collaborative, 2005. *Biomass Resources in California: Preliminary 2005 Assessment*. California Energy Commission. Contract 500-01-016. April 2005.

1.0 Introduction

1.1. Background and Overview

California ranks first in the United States in the total number of dairy cows with approximately 1.7 million on about 1900 dairies, according to Western United Dairymen (WUD), a trade group representing many of the state's dairymen. California is also number one in total milk production, producing about 20% of the United States' milk supply. All of those dairy cows produce significant quantities of manure—about 120 pounds per day of liquids and solids from the average dairy cow amounting to tens of millions of tons of manure annually statewide.[2] Biogas digesters (also referred to as methane digesters) on dairies can help ameliorate some of the impacts associated with that the abundance of manure. Specifically, biogas digesters offer multiple greenhouse gas and air and water quality benefits, as well as potential for new revenue.

Environmental benefits include reduction of greenhouse gas emissions, partial relief from odors associated with manure lagoons, reduction in pathogens (depending on the system used), and improvements in water quality as measured by biological oxygen demand (BOD) and other parameters.

Economic benefits come from electricity sales (where available), avoided purchases of electricity from utilities and fiber or compost that can be sold, and (potentially) carbon credits from methane that is captured and converted to energy.

However, digesters have certain efficiencies and economies of scale. A 1000- or 2000-cow dairy will find it more cost effective to install a biogas digester than a 400- or 500-cow dairy. California's average herd size is about 850 milking cows, and 46% of all dairies have more than 500 head of milk cows, according to WUD. That means the majority of dairies in California have less than 500 cows. In Sacramento County, the average size of dairies is even smaller with less than 20% having over 500 cows.

In order to take advantage of the economies of scale, this study evaluated the feasibility of building a "community" digester where manure is moved to a central location. Also assessed was using a centrally located engine/generator set (genset) for a group of individual anaerobic digesters from closely located dairies. Using a farm "cluster" approach to electricity generation on dairy farms provides an opportunity to use advanced generator technology, such as turbines or lean burn engines, to reduce emissions of nitrous oxides (NOx) and other air pollutants of particular concern to regulators. It is also potentially a more cost effective and labor efficient approach than building and operating smaller, individual on-farm digester power generation or production systems.

2. CIR947 Animal Science Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Original publication date March 1991.

While the technical feasibility for a centralized digester is known, several institutional obstacles must be overcome before a "community" digester or generator set can be built and operated.

One challenge is creating the cooperative business model, including agreements between the dairy businesses, as well as arrangements for selling electricity to the utility and by-products like fiber to suitable markets. This project looked to:

- Assess the barriers to community digester and/or power production facility.
- Develop a business model for a cooperative project.
- Develop a roadmap for dairies to follow, allowing them to successfully implement a community digester and/or genset system.

1.2. Project Objectives

The primary objective of this project was to analyze the barriers to a centralized dairy digester or genset and produce a business plan for building such a facility in Elk Grove, California. Related to this, the project also looked to develop a model of how to establish a dairy community digester and/or central power generating facility that would have broader applicability in California. The project team anticipated the study would demonstrate that an alternative approach to individual on-farm systems to establish dairy digesters could be cost-effective. This is particularly true for smaller dairies that predominate in Sacramento County where economies of scale are greatly influenced by unit cost of digesters and air and water pollution control equipment required.

1.3. Report Organization

The report is organized in three primary sections, or "studies," that track the scope of work and deliverables associated with the tasks for each section. The three study areas including task descriptions that provide the organizational framework are as follows:

Task 1—Evaluation of the Barriers to the Community Dairy Digester Concept in California.

Assess barriers to interconnection, wheeling power, environmental permitting, marketing power or biogas to the utility, and forming farmer collaborations capable of managing a common business venture.

Task 2—Feasibility study of Common Digester versus Common Genset for the Project in Elk Grove, California

Perform technical and economic feasibility studies of a community digester for co-located dairies in Elk Grove, California. Compare the cost and benefit of two different cooperative scenarios at different dairy clusters in Sacramento County. The two scenarios are: moving manure to a central digester and moving biogas to a central genset. The feasibility studies included preliminary design of each concept with cost estimates for design, construction, and commissioning the digester systems, which

included cost estimates of permitting, interconnection, and monitoring each participant's manure or biogas production.

Task 3—Roadmap for Community Digester Projects

The authors developed a business plan for financing the construction of the system, determining the regulatory and market framework necessary for these projects to be successful, and indentifying geographic limitations with regard size and proximity. A roadmap was also developed for other community digester projects to follow, including a plan for managing maintenance costs, benefits, and shared responsibility, risk, and liability. The project team also developed a plan on how to expedite utility interconnection.

This final report summarizes each of these sections and includes a projection of the impact on California's dairies and their potential contribution to renewable generation.

2.0 Project Approach

The project team used three approaches to perform this study:

- In-house file review, interviews, meetings, and phone conversations with knowledgeable researchers, regulators, government policy makers, utility companies, and business developers about the issues particularly relevant to evaluating barriers to community digester systems.
- Field research and data collection on dairies in their Sacramento County study area, including interviews with dairymen and neighbors and discussions with biomass digester technology experts. This was particularly relevant for assessing technical and economic feasibility.
- Literature review, online searches, and financial analysis of other centralized digesters encompassing research studies, business model development, etc. to gain greater understanding of the issues and opportunities. This was particularly relevant to developing the Roadmap. All of this information was distilled and analyzed, contributing to understanding economic and engineering models.

2.1. Interviews and File Review

There are many known barriers and some obscure obstacles to community digester/genset development in California. There was a substantial body of existing information, both published and unpublished, and experience to draw from, including the experience of digester engineering firms and dairymen who had been through the process in California and from the knowledge of the authors in their efforts to develop dairy digesters in California. Regulatory agencies and investor-owned utilities (IOUs) were also involved in the review process in order to incorporate a diverse set of perspectives and understanding related to digesters, with an emphasis on potential issues unique to community systems.

2.2. Field Research and Data Collection

The authors collected field data in order to understand dairy characteristics in the study area, issues of manure management, and opportunities for community digesters/gensets. On-site visits to candidate dairies occurred early in the study to assess their suitability for centralized facilities as well as determine issues related to manure/biogas collection and central location transport. This was instrumental in developing a base case comparison, providing empirical research and data from dairies in the study area and forming the foundation for the economic assessment and technical and engineering feasibility analysis.

2.3. Literature Review and Business Model Development

The research team completed a comprehensive review of the literature related to central farm digesters and community or "cooperative" organizational structures, including reviews of reports from university researchers, government agencies, engineering consultants, etc. The team focused on organizational structures and business models that may be appropriate for central digester management. This was informed by research studies and field experience of digester companies and consultants who were involved in the assessment. This ultimately allowed both for "rules of thumb" and financial software to be produced.

2.4. Task 1—Evaluation of Barriers to Community Digesters

2.4.1. Assess Barriers to Interconnection and Wheeling Power

Dairy biogas digester installations that generate power are considered distributed generators (DG) and are subject to Rule 21, a California Public Utilities Commission (CPUC)-approved and utility-managed process for interconnection to the electricity grid. Specifically, the rule requires self generators of electricity to apply for and receive approval from the local utility to interconnect. Historically, it has been difficult for dairymen to obtain approval and the process has usually taken a year or more.

1. Currently, the IOUs can take as long as they deem fit to approve an interconnection application if errors are found in the application package. A full review of an application by the IOUs should be required before they send it back to the applicant (i.e. identify all deficiencies up front rather than returning it with each deficiency). Currently, the IOUs tend to review an application only to the point of finding any error or omission. Rather than complete the review to identity all errors or omissions, they send the whole application back with only one error/omission indicated. This piecemeal review process causes significant delays.

2. The fees that IOUs may charge to review an interconnection application from a dairy, particularly in regard to Supplemental Reviews, should be reasonable. Applicants believe they are currently arbitrary or excessive. The CPUC should periodically review relevant fees for fairness and consistency of application to ensure they are representative of real cost to the utility.

3. The IOUs have significant discretion on how they handle interconnection. Engineering consultants and dairymen have argued that this has allowed the IOUs to require the installation of expensive, unnecessary, and excessively redundant protection technologies not required in other states. There should be a provision (in legislation or by CPUC ruling) for an appeals process to the CPUC that would allow aggrieved parties to find redress for their concerns.

4. IOU personnel who review interconnection applications impose disparate requirements, depending on who is performing a site visit or reviewing a

drawing. It is recommended that IOUs have one designated person who communicates all requirements in writing. If an IOU changes requirements in mid-process, the utility should assume at least a portion of any added expense.

If there is a willing seller and a willing buyer, both looking to enter into a contract for electricity from a dairy digester, it may be feasible to wheel the power. However, there are other hurdles, including the cost of wholesale wheeling. Setting up the transaction would entail charges that could likely include an ancillary service fee, uplifting charge, and wholesale wheeling access charge. This is highly relevant here because a centralized digester may achieve the size necessary to export power through the California Independent System Operator (ISO). The ISO could be expensive, however, costing tens of thousands of dollars. It is difficult to find any instance where this has been done with DG under current rules and circumstances. It would require breaking new ground without a certain outcome, and the transaction cost for doing so may be prohibitive.

2.4.2. A Report on Barriers to Marketing, Environmental Permitting, and Dairy Association Formation

Assessment of Environmental Impacts of a Community Digester

Potential incremental environmental benefits of community digesters or gensets include:

1. A centralized facility can allow for more efficient use of resources such that building a central system can be more cost-effective than building digesters and/or gensets on individual dairies. This efficiency advantage will be a function, in part, of the distance manure is hauled by truck to a central facility, or, if the manure and/or biogas are to be piped to a central facility, the sizing and distance of pipeline required.
2. If a centralized digester is built, the primary alternative for moving manure instead of hauling it is to move it via pipeline, in slurry form. Moving the manure via pipeline is preferred over trucking, but has its drawbacks:
    a. The piping would be large and therefore expensive to install.
    b. The volume and high percentage of solids in the mix would require high-pressure pumping to move the manure.
    c. The system would require a high degree of maintenance.
    d. The slurry is not pumped efficiently over long distances. Under a mile and a half is preferable.
3. A centralized genset allows for pollution control technology that is not feasible on smaller individual dairies. For example, a large engine that generates 250 kilowatts (kW) or more provides an opportunity to purchase a lean burn engine with fewer emissions than a rich burn engine. This reflects the lack of domestic manufacturers making lean burn engine/gensets with lower name plate ratings.

There is also an economy of scale when employing scrubbers and catalytic converters for removing hydrogen sulfides and air pollutants.

4. The air pollution impact is avoided when biogas is moved to a central location instead of trucking manure. If manure is transported by truck instead of transporting biogas by pipeline, there is potential for more air pollution as diesel trucks are typically employed to move the manure, and they emit NOx, hydrocarbons, particulate matter (PM), volatile organic compounds (VOCs), and other air pollutants that would not occur with pipeline transport.
5. From a financial and environmental perspective, moving the biogas may be preferable depending on the distance involved. Moving the biogas to a central generator facility may be more attractive than pumping manure because:
    a. The lines are less expensive to install.
    b. The lines are low pressure, requiring smaller motors to move the gas than the manure.
    c. The system would require a low level of maintenance.
    d. The piping is efficient over longer distances.

Many dairies have an excess of nutrients and salts on their grounds. Exporting manure nutrients off the farm is sometimes necessary to achieve nutrient management plan objectives. This process could be facilitated with a central receiving location where manure is digested, and solids are sold to a manure hauler/composter for use in nearby agricultural areas. Further, liquid effluent from a central digester could be treated to remove excess nutrients and salts more cost-effectively than if individual treatment technologies were installed on each dairy. The net benefit for the dairies involved could be an improvement in water quality (i.e. less salts and nitrates in groundwater).

A central generator, by its nature, produces power at one location equivalent to the combined power of individual gensets. This minimizes costs and processes that are often problematic for individual operations. For example, there are transaction costs associated with interconnection to the electric utility and of trading both greenhouse gas and renewable energy credits. A central facility can engage in such transactions as an "aggregated facility" more cost-effectively than conducting these transactions at the individual operation level. This makes these digester facilities more accessible to the greenhouse gas offset market, which can help create incentives for new digester construction.

Regulatory Issues Surrounding Community Digester Permitting Requirements in Sacramento County

One of the major issues in permitting methane digesters on California dairies is the differing requirements between regions (Regional Water Quality Control Boards and Air Districts) and within regions (each county may have its own set of regulations or policies that tend to differ from neighboring counties). An added problem is the dynamic nature of the process as both the Regional Air and Water Boards are still in the formative stages of implementing new requirements. For example, in the Central Valley Regional Water Quality Control Board area, covered lagoon digesters will likely have to meet a groundwater protection standard equivalent to a hazardous waste facility. On the air quality side, the engines that combust the biogas may have to meet "ultra clean" requirements for air emissions in the San Joaquin Valley Air Pollution Control District, including a NOx standard that will be hard to achieve in practice, although this is not a certainty. Both of these expensive air pollution control technologies and dairy lagoon liner requirements will make these facilities much more expensive to build. This reinforces the benefit of installing a community system.

Marketability of Products from a Community Digester System

A summary of potential opportunities for cost savings and/or revenue generation was developed during this project and follows in Table 1.

Table 1. Summary of potential savings and revenue generation from community digester systems

Output	Value	Ownership
Power	kWh rate	Owner of generator
Waste Heat	BTU rate	Owner of generator
Digested Fiber	$ per ton	Owner of digester
Renewable Energy Certificates	$ per kWh	Owner of generator*
Production Tax Credits	$ per kWh	Owner of generator
Digester Carbon Credits	$ per kWh	Owner of digester*
Generator Carbon Credits	$ per ton	Owner of generator*
Depreciation	% of investment	Titleholder of equipment

*Note: SMUD acquires these items in exchange for energy and capital cost incentives.

Source: Sustainable Conservation

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For projects under 1 megawatt (MW), power (electricity) sales by the community digester to the Sacramento Municipal Utility District (SMUD) would be compensated at retail rates up to the net amount used by the dairies (that is about 10 cents/kWh) and energy sales above the net are compensated at a negotiated rate that will climb as the market price for renewables climbs. That has been agreed to in advance by SMUD through its Biomass Interconnection Agreement. However, the sale of electricity to an IOU such as PG&E or Southern California Edison (SCE) is more speculative. The CPUC has approved tariffs for electricity sales but approval challenges have delayed final tariff

adoption. It is likely that any such sale will be in the 8 cents per kWh range in the future. There is an assumption built into this report, though not verified, that a GHD Inc. digester produces more than twice the biogas of a covered lagoon, thus yielding significantly higher electricity sales.

Waste heat value is dependent on how it is used. No specific monetary attributions have been made as part of this report. However, waste heat that is recirculated to the digester (as a GHD design accomplishes) raises the temperature and increases the metabolic rate to accelerate biogas production. This has a significant impact on digester performance.

Digested fiber has substantial potential value as a marketable commodity or as bedding for the cows. This report uses a conservative projection of $15,000 with a 1900 cow dairy assumption. It is projected that the higher use value will be a substitute for Canadian peat moss, providing substantially more revenue if this market proves viable.

Tradable Renewable Energy Certificates (RECs or TRCs or green tags) are created when a renewable energy facility generates electricity. Each unique certificate represents all of the environmental attributes or benefits of a specific quantity of renewable generation, namely the benefits that everyone receives when conventional fuels, such as coal, nuclear, oil, or gas, are displaced. Renewable energy certificates provide certificate holders with the benefit of displacing other non-renewable sources from the regional or national electric grid. A list of brokers, buyers, and sellers of RECs may be found at: http://www.greene.org/your_e_choices/trcs.html.

The Production Tax Credit (PTC) is a per kWh tax credit for electricity generated by qualified energy resources. The PTC provides a tax credit of 1.5 cents/kWh for wind, closed-loop biomass, and geothermal energy sources, adjusted annually for inflation. The adjusted credit amount for projects in 2005 was 1.9 cents/kWh. Electricity from open-loop biomass, small irrigation hydroelectric, landfill gas, municipal solid waste resources, and hydropower receive half that rate—currently 0.9 cents/kWh. The PTC for a biomass project as envisioned in this study would be approximately 0.9 cents/kWh and would remain an asset of the owner of the facility.

Carbon Credit is a new concept devised by public and private entities. The concept involves buying carbon units, mainly in tons, through a middle entity that aggregates contracts from many farmers who meet the criteria of carbon sequestration through adopting conservation practices. The carbon units are then sold to a buyer in the industrial sector needing to offset the carbon dioxide (CO_2) generated to the atmosphere through their manufacturing activities. Methane, which is 21 times more powerful than CO_2 as a greenhouse gas, can be traded in carbon equivalent units. Currently, a ton of carbon (or carbon equivalent) trades in the $2 to $3 per ton range. That is anticipated to go up over time as state and federal regulations mandate reductions in the future.

Assess the Challenges Facing the Development of Dairy Associations Formed to Operate Community Digesters

The larger the number of dairies participating in the project, the more important it is to have a structure that allows for maximum participation and potential return for each farmer, based upon individual contributions. In some cases, especially where each participant wants to be actively involved, the most logical organizational structure would be a cooperative, not unlike the milk/produce cooperatives most dairy farmers are familiar with. Again, the assumption is a large number of interested participants.

For the case study of three dairy clusters in Sacramento County, only two dairies were found suitable for participation. The organizational structure that was found most viable was a Limited Liability Company (LLC). In an LLC, which is similar to a limited partnership, one participant/entity takes the lead as the "managing partner," while the other participants remain passive members. A trust factor is required, because the passive member(s) have no control over the decisions of the LLC (unless there is gross neglect or another reason to replace the managing partner). Normally, the LLC does not depend on the passive members beyond their initial contribution of cash or other assets. From that point on, the LLC stands alone on its ability to develop, finance, own, operate, and manage its assets/business.

The time and energy commitment would be significant for any one of the participating dairymen, perhaps more than anyone would want to contribute. The alternative would be to secure the services of a third party as the managing partner and create incentives for the managing partner to ensure success. In return, that would dilute the individual dairy's return while increasing the odds that the project would have proper oversight.

2.5. Task 2—Feasibility Study of Community Digester

2.5.1. Centralized Dairy Digester With Power Generation

This part of the study evaluated the feasibility of a community digester in Galt and Elk Grove areas (Sacramento County), looking at specific dairies or dairy clusters with qualifying characteristics. Three scenarios were evaluated: (1) a central digester with a central combined heat and power (CHP) unit; (2) a central CHP unit receiving biogas from digesters on each individual dairy; and (3) a digester and CHP unit on each individual dairy.

The study determined that the number of cows that could provide manure into a central digester was lower than initially anticipated. Preliminary indications are that some dairy owners do not want to participate in the project and/or they do not want to contribute financially to the project. Another dairy owner had previously committed to an anaerobic digester, and would be at risk of losing financial assistance if the project was modified. That project would be in operation before construction would start on a community digester.

The increasing growth rate of the area surrounding Elk Grove may not be favorable to a community digester in the long term. The duration of dairy farming in Elk Grove is in

question due to the rapid growth rate in the area. Developers are offering farmers substantial amounts of money for their farmland so they can turn it into residential or commercial zones. With the subprime loan problems and down turn in the housing market, development pressures have eased. This may or may not be a short lived reprieve.

Only two of the six dairies studied turned out to be viable participants. These two dairies have a combined size of approximately 2000 wet cow equivalents, which is midway in the spectrum for required manure input to make a community digester financially feasible. Even with 100% participation from all six dairies in this study, each dairy would need to be fully committed to ensuring the success of the digester for the next 10 years.

Summary of Costs for Elk Grove

It is important to recognize the digester technology used for these estimates are GHD-designed digesters, which are typically plug flow, complete-mix systems that consist of an in-ground concrete vessel that utilizes waste heat from the CHP unit to increase biogas production. These digesters tend to be more expensive than some other designs, such as those installed by RCM Industries. The reason for this difference relates to the nature of the design that GHD employs (i.e. settling basins and concrete roof) and purported better system performance and gas yields. No judgment has been rendered in this report on such claims.

Summarized below in Table 2 are estimated costs of digester systems based on cow numbers.

Table 2. Costs of digesters (costs are rough estimates based on number of cows and not actual quotes)

Digester & CHP unit cattle counts	Cost
2000 wet cow equivalent	**$1.85 million ($400,000 for genset)**
1500 wet cow equivalent	**$1.6 million ($325,000 for genset)**
1000 wet cow equivalent	**$1.15 million ($211,000 for genset)**
Below 1000 cows, GHD digesters are not recommended based on their cost and returns	

Source: Sustainable Conservation

Additional Costs Associated With Digesters for Flush Dairies Only

A Settling Basin to separate solids and provide clean flush water (solids go to digester) would average $130,000 to $230,000 for dairies in the 750 to 2000 cow range. This would be required for each dairy that uses a flush system, even with a community digester.

For the Elk Grove dairies, the digester costs were estimated based on the wet cow equivalent from the actual cow numbers (calculated by taking the total number of milking cows plus ½ of the dry cows and ½ of the springer heifers, and decreased by 25% due to the manure that is not available for collection from the dry lots or exercise

pens during the summer months). The cow numbers were rounded up or down to sizes listed above to determine digester prices. Actual output from the different scenarios evaluated may vary depending on the generator chosen and efficiency of manure collection. Generator manufacturers have different efficiencies for specific models. In many cases, there may not be a generator sized to meet the exact biogas production projected so the generator may be somewhat under or oversized for the application and run less efficiently.

Additional Costs Associated with the Central Digester or Central CHP Unit or Both

Price per linear foot for underground manure pipe from each dairy to central digester (same pipe will transport digester effluent back to the individual dairy's storage system) is $11/ft for pipe installed and backfilled plus $15,000 for pumps per dairy (not applicable for the dairy that has the central digester and central CHP unit). The price per foot for underground gas pipe from each dairy's digester to central CHP unit is $11/ft for pipe installed and backfilled plus $12,000 for pumps per dairy (not applicable for the dairy that has the central CHP unit).

The total cost for the selected community system is more than $2 million dollars when the settling basins, pipeline installations, and gensets are added to the cost of the digester. A larger community system would have better economy of scale but there are relatively few options for such systems in Sacramento County. Bringing offsite waste onto the dairies would change this dynamic but that solution has other shortcomings identified earlier, particularly related to difficulties of gaining regulatory approval.

2.6. Task 3—Roadmap for Community Digester

2.6.1. Monitoring Plan

For a community digester to be successful, the participating dairies need to determine who will monitor and manage the project once it is in operation. Monitoring will involve activities both inside and outside the generator facility. The mechanical issues will need to focus on the operation of the genset, water recirculation, and gas recirculation that should be checked frequently. Outside of the mechanical building are manure influent pumps, effluent pumps, and an effluent separation system that need monitoring.

This individual who does the monitoring could be a dairyman who is involved in the project or someone who is not involved but is hired to perform the required duties. The same individual may perform the maintenance and management duties or they can be split. It is important for all participants to agree and feel confident about the ability of the individual(s) who will perform the daily monitoring of the digester and coordinate the scheduled and unscheduled maintenance.

2.6.2. Plan for Managing

The management tasks include coordinating and monitoring the input of the participating dairies and determining the power production. With only two dairies as "anchors" for the community digester in the selected scenario, it is preferable that the

management structure be commensurately simple. That would suggest a contractual arrangement. A co-op arrangement is probably unnecessary in either context. A contract outlining roles and responsibilities seems preferable because it is simple and because dairymen are familiar with contracts. It would involve hiring an attorney to prepare the contract and having another attorney review it while negotiating terms that satisfy all parties.

One other option is to hire an outside third party to build and/or operate a digester system. Microgy, a company that builds and operates digesters, could serve as a model, although whether or not they would be the most suitable for performing both the management and maintenance function remains to be demonstrated.

2.6.3. Plan for Permitting

In California, environmental permitting issues play a large role in whether or not installing a digester is feasible or desirable. It is important to know their role.

The agencies involved in permitting digester projects in Sacramento County include the Central Valley Regional Water Quality Control Board (RB-5), the Sacramento Metropolitan Air Quality Management District (SMAQMD), potentially the California Integrated Waste Management Board (CIWMB), and the local Elk Grove (or Galt) municipalities.

California Environmental Quality Act

The overriding permitting issue for this project is the California Environmental Quality Act (CEQA). This should be addressed first, as most of the agencies cannot issue permits until CEQA requirements are met. There is some discrepancy in opinion about whether individual digesters and CHP units will trigger CEQA; however, it is very likely that both centralized scenarios will trigger CEQA—particularly the option of piping biogas to a centralized CHP unit. This responsibility would fall on the local permitting authority (City of Elk Grove or Galt, or Sacramento County).

Sacramento County Permits

The departments involved in permitting this project in Sacramento County are building, planning, and technical services. In addition, the Elk Grove Fire Department (or Galt) would need to issue a fire permit. The Sacramento County Planning Department would review the proposed project to ensure the proposed use is appropriate for agricultural zoning. The Elk Grove dairy already went to the Sacramento County Planning Department and received word that the digester is "incidental and accessory" to the permitted dairy agricultural operation. In general, the planning department does not anticipate that this will be an issue as anaerobic digesters are appropriate for dairy zoning.

Permitting Requirements for the Sacramento Metropolitan AQMD

The AQMD air permit application and related guidance documents can be found on the district's website: http://www.airquality.org/permits/forms/appforms.shtml. The application form is titled "Form ICE 100 Internal Combustion Engines" and asks for

information such as engine specifications, purpose and hours of use, and emission factors for NOx, Reactive Organic Compounds (ROC), NOx plus ROC, carbon monoxide (CO), sulfur oxides (SOx) and PM.

The AQMD has a limit of 5000 pounds/quarter for NOx and SOx from each genset. A centralized genset would be treated the same as individual gensets on multiple dairies. It is not certain that current engines and controls will meet these limits. If emissions from the project engines exceed these limits (see Table 3 below), AQMD states in their guidance document referenced above "prior to approving an Authority to Construct application for a new or modified stationary source or emissions unit which has an increase in potential to emit exceeding any of the following limits, the District must submit a preliminary decision to the California Air Resources Board (CARB) and the U.S. Environmental Protection Agency (EPA) for review and publish the preliminary decision soliciting public review and comment at least 30 days prior to final action on the application."

A centralized generator will face AQMD requirements (described above) whether it is on an individual dairy or at central location. The 5000 lbs/quarter of emissions would apply to the centralized generator just as it would apply to individual digester generators. There is no break for combining gas from multiple digesters into one centralized generator as far as this limit is concerned (i.e. the limit would *not* be spread among the dairy association members—it will be treated as if the central generator is one applicant).

Table 3. AQMD emissions limits

Pollutant	Pounds/quarter
Reactive Organic Compounds (ROC)	7,500*
Nitrogen Oxides (NOx)	7,500*
Sulfur Oxides (SOx)	13,650
PM_{10}	7,500
Carbon Monoxide (CO)	49,500

* Emission limits for ROC and NOx have been reduced to 5,000 pounds/quarter

Source: Sustainable Conservation

Emissions of NOx will likely be of the most concern. If NOx does exceed the emission limits in Table 3, there may be opportunities to compensate with emissions offsets. The "offsets" are measured on a facility basis.

Region 5 Water Resources Control Board Permitting Requirements

The first step for permitting from the regional water board is to contact the agency and let them know what is proposed. It is likely that the dairy or dairy association will need to file a Waste Discharge Report (WDR). In the Sacramento area, RB-5 is the operative agency. The filing would be reviewed to determine whether a WDR will be issued. It is possible that individual digesters that simply involve covering an existing lagoon may

not need to file a WDR with the RB-5. However, any new construction of lagoons or in-ground structures will require a Waste Discharge Report.

The central issue for the RB-5 is the nature of the digester—does it involve simply covering an existing pond or will a new pond or in-ground structure be constructed? If the digester simply involves covering a lagoon, with no expansion (deepening or widening), at this point RB-5 staff have indicated that there may be no need to impose additional requirements.

If the digester involves new impoundments, staff is limited to applying existing regulatory language. New design specifications (TIER 1) will likely require a double liner with a leachate collection system. The only alternative is to propose an alternative design along the lines of the Natural Resources Conservation Service (NRCS) "practice standard" and perform a modeling study to demonstrate the installation would not adversely impact water quality. The latter option would be expensive, have no required review time (it could take months or years), and may not be approved. The water board is looking for a guarantee of non-degradation of ground water, and it would prefer an entirely above-ground digester system. It is possible to construct an above-ground complete mixed digester, although it is significantly more expensive. The University of Florida dairy uses an entirely above-ground fixed-film digester for flush water that may be appropriate for dairies in California. This option is being looked at to demonstrate the suitability of technology in the region.

According to RB-5 staff, specific steps needed for individual dairy digester permits are as follows: (1) file report of waste discharge; (2) work with staff to come up with an agreement on what is needed; (3) wait at least six months for a response while the report goes into the queue for WDRs. Currently, the RB-5 is very understaffed and the range of time that can be expected for permitting approval is ambiguous. Once the report of waste discharge has been filed and the dairy and staff have agreed on all of the information, they would send a letter saying all issues are resolved and they are working on a WDR. It generally takes six months to write a WDR (including time for public notice).

2.6.4. Plan for Utility Interconnection

The barriers to utility interconnection primarily apply to outside of SMUD territory. Historically interconnections have taken up to a year or more. Currently there are two proposed tariffs that may or may not streamline the process but they have not been formally adopted. However, there are steps that can be taken to minimize approval time. The recommended steps are as follows:

1. Hire a professional electrical engineer, preferably one who has worked at an IOU. These engineers understand the technical issues, know the language IOUs speak, and are conversant in how the process works, particularly in what the IOUs are looking for.

2. Talk to other dairymen and/or distributed generators to learn from their experience. This can be invaluable as they have already made the mistakes that can, in many cases, be avoided. The savings in time and money are worth the effort.

3. Learn about the costs and benefits of interconnection from those who have been involved in dealing with the issues. In California, WUD, one of the dairy industry trade associations, has evaluated and quantified the financial costs and benefits of interconnection on individual dairies in California.

4. Maximize onsite use of self-generated electricity. Exporting power at wholesale rates and then importing it back in at retail rates is disadvantageous financially compared to using as much power onsite first before exporting it. To make net metering work effectively for dairies, rewiring the dairy, or participating dairies, to maximize onsite consumption of power is beneficial.

5. Make sure that interactions with the utility are documented in writing and request written confirmation from the IOUs as to what they have agreed to do or not do. A paper trail will be important when there is a need to rectify problems or respond to situations such as the utility assigning a new individual to complete the interconnection process.

6. Communicate often with the engineer and/or consultant to track progress and identify delays in the process. It is a mistake to assume that the utility will proceed expeditiously to handle the interconnection process.

7. Be both professional and polite in your interactions with the utility. Disparaging comments or inflammatory language rarely expedites approval.

The steps recommended above will not ensure that the interconnection process will go smoothly. However, without them an applicant is almost assured to have delays, while by following the guidelines there is a higher probability for faster and less costly approval.

2.6.5. Dairy Association Business Plan

California Dairy Industry Business Climate

California's dairy industry is currently under threat. There are several sources of threats, both short- and long-term, that could influence producer willingness to partake in new ventures, particularly related to investments in methane digesters. Short term threats include: (1) record low prices for milk that have resulted in the loss of approximately 100 dairies during the last year. Many of these dairies were smaller in size, giving them a competitive disadvantage as unit costs are less for larger dairies; (2) the year 2006 saw dramatic declines in milk production during the hot summer months and a record number of cows died from the long heat wave that occurred; and (3) new Central Valley Regional Water Quality Control Board permit requirements were adopted in 2007. These Waste Discharge Requirements will make the environmental compliance cost of

operating a dairy significantly more expensive. Of particular relevance is the higher level of groundwater protection requirements for dairy ponds, with new liner and water monitoring provisions included in the Waste Discharge Requirements. Because methane digesters are manure containing vessels, they will have to meet these expensive new standards.

Organizational Structure

The Dairy Association Business Plan evaluated several organizational structures for implementing a "community" dairy methane digester, including a Contractual Relationship, General Partnership, Limited Partnership Corporation, Limited Liability Company, and Cooperative. Based on the analysis, an LLC was selected as the preferred alternative because it provides the greatest benefits in comparison to other options. The LLC formation offers several advantages to its dairy participants. Most importantly, it will quantify and limit each participant's involvement/risks to some degree. The legal structure requires that there be a "manager" to tend to the LLC's business and make decisions on behalf of the LLC, including application for any loans and/or grants, supervision of the operation (either directly or through a third-party contract) and attention to all legal, tax and reporting matters. During the formation of the entity, all LLC members have a say in the structure and operation. After the formation, the managing partner will be free to operate within the bounds set during the LLC's formation. The LLC also accomplishes many asset protection goals. It allows creation of a legal entity that avoids many of the tax and business problems inherent in the corporate and partnership structure. It also provides a means for individuals to conduct their financial and business affairs in an efficient and convenient manner without the restrictions, formalities, and liabilities associated with those other entities.

Marketing Plan

In addition to electricity sales, the other significant revenue stream (at least from a plug flow digester) is fiber (covered lagoons have more limited options). Fiber is separated from the manure post digestion. As such, it has undergone pathogen reduction (plug flow digesters operate at temperatures high enough to kill most pathogenic organisms) and has marketable value. There are currently three primary options for reusing the fiber: bedding, composting, or selling to wholesale organic products companies. Bedding is the lowest value use because no additional revenue is captured and existing corral manure can help serve this purpose, so there is only a modest cost savings of about $5000 annually. A second option is to compost the fiber and sell it to landscapers as a soil amendment (about $15/ton). This is a viable market option but may not capitalize on the fibers' optimal value. The third and preferred current market is to sell the fiber to a wholesale organic products company. There is a high demand option for high quality, pathogen-free manure fiber among organic products manufacturers. In the future there may be a market as a peat moss substitute for an even higher value (about $40/ton).

Business Case

It is estimated that during the 10-year period of the pro forma analysis, the digester project would provide approximately $1.3 million in financial benefits (net of debt payments), mainly divided between electricity and fiber sales, but also avoided electricity purchase. There are additional monetary benefits from reductions in greenhouse gas emissions (not included in this assessment). The simple payback period, assuming total project cost of $2.4 million and an initial grant of $500,000, is approximately 7.8 years. That will be attractive only to a minority of dairymen. That could change if capital was made available at no cost to the dairymen to build and operate the necessary infrastructure. However, the community dairy digester facility evaluated here was on the smaller end in terms of size, at only about 2000 cows contributing to energy production. A larger digester facility receiving manure from more cows and participating dairies would be more attractive financially. In any scenario, the marketability depends on how much grant money can be acquired.

2.6.6. Roadmap for Community Digester Projects

The critical considerations for a digester project, either community or individually, includes the size of the herd, volume of waste, and source and amount of funding. The larger numbers of cows that contribute to a digester or genset system, the better the opportunity and conversely, the smaller the number of cows providing fuel for a digester or genset system, the less attractive is the potential for a community (or individual) system. However, grant funding can reduce the number of cattle needed to make a project feasible. This reduction in threshold size will be commensurate with the amount of outside funding that can be applied. But practical considerations, like available size of genset, may limit what might be feasible for any given operation.

The assumption for this report is that flush dairies predominate in California and that instead of moving manure liquids by truck, as is typically done on scrape dairies, manure will in most cases have to be transported by pipeline. Flush dairies will have manure solids in the 1 to 2% range, while scrape dairies can have manure solids of up to 10% or more. Moving manure liquids from a flush dairy by pipeline (or alternatively the biogas from covered lagoons) is generally cheaper and easier than trucking solid or semi-solid manure as is typical on a scrape dairy. Under either of these scenarios, there is no hard and fast rule regarding geographic limitation for a cluster of dairies moving manure or biogas around by pipeline because the conditions that affect the cost and feasibility of transporting manure or biogas are specific to each site. However, there are practical limitations that limit hauling distance.

If the project hinges on the sale of power, rather than just producing power for farm use, then the project should preferably look to obtain the current market price for the electricity. Municipal utilities, like SMUD, have the ability to contract for renewable energy using power purchase agreements (PPAs).

IOUs have not offered PPAs until recently and the tariffs associated with those PPAs are still under development.

There are two other options in California for a community digester:

1. Sign a net metering agreement that will allow owners to offset their own use and avoid paying the utility for electricity. However, owners will not be able to sell the surplus power back to the utility under a net metering tariff.
2. Sell the excess power to a direct access third party via a wheeling agreement with a Certified Scheduler.

Option 2 would increase operating costs/liabilities, and therefore would only be a viable option where there is a large amount of excess power available.

It is important to recognize that irrespective of where the waste comes from, permitting will be both time consuming and expensive. Obtaining approval from any of the regional water boards may be difficult. But the RB-5 has proven particularly challenging. Allowing a year or more to gain the approvals would be wise. In 2007, RB-5 issued new Waste Discharge Requirements for dairies that make for expensive and uncertain outcomes for digesters.

A permit from the relevant AQMD for the engine or flare emissions should take about four to six months to complete, where the proposed technology can meet regulatory requirements. As of this writing, the San Joaquin Valley AQMD is requiring that "ultra clean" emissions standards be met. It is currently not evident that dairies will be able to consistently achieve this with any available pollution control technology, short of upgrading biogas to pipeline quality and using fuel cells.

3.0 Project Outcomes

3.1. Summary of Findings From Task 1—Barriers to Community Digester

The barriers to interconnection of dairy digesters are primarily institutional, specifically related to the internal approach used by the utilities to approve the interconnections. The process tends to be long (a year or more), seemingly arbitrary, and potentially costly. However, these barriers can be surmounted either legislatively or through changes in the applicable tariffs adopted by the CPUC. However, recent efforts by the IOUs to improve the process along with increasing interest in expediting CPUC approvals by the CPUC suggest that the interconnection process could improve in the future.

If there is a willing seller and a willing buyer, both looking to enter into a contract for electricity from a dairy digester, it may be feasible to wheel the power. That means that even if dairymen are unable or unwilling to sell electricity directly to the utility, they can use the utility's power lines to sell to a third party. However, the process may be costly, time consuming, and risky as this option has not yet been fully consummated in practice.

Environmental permitting for dairy digesters in California will be expensive and time consuming. New requirements by the California Air Resources Board and San Joaquin Valley AQMD require costly catalytic converters and other equipment to achieve ultra clean emission standards from the biogas engines. Also, the Central Valley Regional Water Board has adopted a Waste Discharge Requirement that effectively mandates a double liner system for any in-ground digester installations. This will be very expensive to install.

On the issue of power sales, dairies in SMUD territory would be able to sell directly to the utility. For dairies outside of SMUD territory, the situation is more complex. Tariffs have been developed that will require IOUs to buy electricity. However, the tariffs are currently being challenged and it is uncertain what the final outcome will yield.

The preferred organizational structure for a community digester and/or genset is a Limited Liability Company. The LLC formation offers several advantages to its dairy participants. Most importantly, it will quantify and limit each participant's involvement and risks. The structure also allows, during the formation of the entity, the ability of all LLC members to have a say in the operation, much like a cooperative. An LLC allows creation of a legal entity that avoids many of the tax and business liability problems inherent in the corporate and partnership structure. It also provides a means for individuals to conduct their financial and business affairs without the restrictions associated with cooperatives, partnerships, and contractual relationships. However, it is possible that new models of collaboration, such as a third party owner/operator, may emerge in the future as a more attractive alternative.

3.2. Summary of Findings From Task 2—Feasibility of Community Digester

Of the six dairies that were studied for the community digester system, only two turned out to be possible participants (Van Leeuwen and Mello dairies). Those two dairies have a combined size of approximately 850 to 1020 wet cow equivalents, which is on the lower end of the spectrum for required manure input to make a community digester financially attractive. The authors selected one central digester with manure piped about a third of a mile to the central location as the best option. Moving the manure by truck was found not to be cost effective.

The total cost of the digester system, which includes the digester itself, settling pond, the CHP unit and genset, is approximately $2 million. Additionally, the research team found that the 1600 feet of pipe required to move manure costs approximately $11/ft plus $15,000 for pumps, for a total of $32,600 to move the manure.

These results are highly site specific and the economics would likely be different on other dairies in California. What will likely be constant across dairies and dairy clusters is the benefit of having high energy density—lots of manure in close proximity and centralized facilities to create the biogas or generate the energy.

3.3. Summary of Findings From Task 3—Roadmap for Community Digester

It is estimated that during the 10-year period of the pro forma analysis, the digester project would provide approximately $1.3 million annually in financial benefits divided between electricity and fiber sales but also avoided electricity purchase. This is based on an initial investment of approximately $2 million plus the capital cost of putting in a pipeline to move the manure (the most attractive option in the case study). The availability of grants from state and federal sources can contribute to the financial success. Although this analysis was case specific to dairies in Sacramento County, it is reasonable to extrapolate that where there are clusters of dairies or where there is a high concentration of manure in close proximity, there is a greater potential for a community system to work. Alternatively, where the dairies are small and far apart, it would be much more difficult to justify a community system without offsite materials.

Overcoming barriers identified in the report will be critical for community success. New legislation, regulations, or policies may be needed if barriers are to be overcome.

4.0 Conclusions and Recommendations

4.1. Conclusions

Of the six dairies that the authors studied for the community digester system, only two turned out to be possible participants. Those two dairies have a combined size of approximately 2000 wet cow equivalents, which is midway in the spectrum for required manure input to make a community digester financially attractive. The selected scenario was one central digester with manure moved by pipeline about a third of a mile to the central location. Moving the manure by truck was not cost effective.

These results are highly site specific, and the economics may be different on other dairies in California. What will likely be constant across dairies and dairy clusters is the benefit of having high energy density—lots of manure in close proximity and using centralized facilities to create the biogas or generate the energy.

The preferred organization structure for a community digester and/or genset is a Limited Liability Company. The LLC formation offers several advantages to its dairy participants. Most importantly, it would quantify and limit each participant's involvement and risks. All LLC members have a say in the structure and operation during the formation of the entity, much like a cooperative. In addition, an LLC allows creation of a legal entity that avoids many of the tax and business liability problems inherent in the corporate and partnership structure.

Where a plug flow digester is used, namely on a dairy that relies on a scrape system of manure collection, there is a significant revenue opportunity from fiber sales. Because most dairies in California, at least in the Central Valley, rely on flush systems and are therefore likely to use covered lagoon digesters, this revenue stream will likely not be available, at least not as a high value co-product unless additional pathogen reduction measures are used, like high temperature composting. However, covered lagoons can be less costly to build and maintain and new revenue streams, like greenhouse gas credits, could make all types of facilities more attractive in the future.

Regulatory consideration may be the overriding variable to determine what types of systems are commercially viable. Water and air quality regulations currently are inhibiting broader adoption of digester technology. That may push new types of systems and approaches, including third party owned and operated centralized systems.

4.2. Commercialization Potential

The opportunity for widespread adoption of the community digester/genset concept will depend primarily on overcoming the barriers and issues identified in this report. Currently, electricity sales to utilities from dairy digesters have only occurred in limited areas of the state, primarily in SMUD service territory. That has to change if digester technology, whether individual or community, will become more widespread. The interconnection issues, regulatory hurdles, and ownership of the renewable energy credits will have to be addressed as well. Factors specific to community systems, such as

the organizational structure, will likely require that enough of these systems are built and demonstrated if California's dairymen are to become comfortable with this approach.

4.3. Recommendations

It would be useful to further update the information in this report by evaluating new digester facilities in planning, or in the process of installation in California, that use a centralized processing system (whether it be a digester or genset). That may suggest other options that are workable going forward.

It would also be useful to research digester technologies suitable for flush dairies that have the benefits of a plug flow system. Fixed film digesters for example may also produce a valuable fiber product (from pathogen reduction properties) or provide other benefits that covered lagoons typically do not.

One other issue is the cultural factors that influence dairymen's perspective on community digester systems. Dairymen tend to be independent by nature and may influence what types of collaborative projects that they are willing to participate in. Gaining a greater appreciation of those factors would be useful to understand what opportunities may be more acceptable to dairymen if the state is to achieve much broader adoption of digester technology within this industry sector.

4.4. Benefits to California

California has nearly 1.8 million mature dairy cattle in the state and a nearly equal number of support stock. If all the resultant manure were put in digesters, the estimated gross potential for methane digester technology in terms of carbon equivalents is 6.1 million metric tons carbon dioxide equivalent ($MMTCO_2E$), according to CARB.[3] Collecting and utilizing all this manure is not feasible. CARB also estimates, in that same document, that the technical potential for methane capture from dairies is about 3.1 $MMTCO_2E$, with an aggressive investment and development program. Currently, less than 1% of dairy manure in California is being processed in anaerobic digesters, so the opportunity is substantial.

According to a California Biomass Collaborative report, if manure digesters captured all available dairy manure and utilized the methane rich biogas to generate electricity, up to 350 MW of new renewable energy production would occur.[4] However, the report states that less than half of this is technically feasible.

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3. California Air Resources Board. 2007. "DRAFT California Greenhouse Gas Inventory". Updated 8/22/07. At www.arb.ca.gov

4. California Biomass Collaborative, 2005. *Biomass Resources in California: Preliminary 2005 Assessment*. California Energy Commission. CEC-500-2005-066-D. April 2005.

Digesters need to be looked at from a comprehensive perspective. They are not only energy generators and destroyers of greenhouse gases, but they are also a means to reduce odors, improve water quality, potentially improve air quality, and provide additional financial security for dairymen. An economic and organizational model that encourages their adoption is critically needed.

Glossary

AQMD	Air Quality Management District
BOD	Biological oxygen demand
CARB	California Air Resources Board
CEQA	California Environmental Quality Act
CHP	Combined heat and power
CIWMB	California Integrated Waste Management Board
CO	Carbon monoxide
CO_2	Carbon dioxide
CPUC	California Public Utilities Commission
DG	Distributed generators/generation
ESP	Electric service provider
Genset	Engine/generator Set
IOUs	Investor-Owned Utilities
ISO	Independent System Operator
kW	Kilowatt
LLC	Limited liability company
$MMTCO_2E$	Million metric tons carbon dioxide equivalent
MW	Megawatt
NOx	Nitrous oxides
NRCS	National Resources Conservation Service
PG&E	Pacific Gas and Electric
PM	Particulate Matter
PPAs	Power purchase agreements
PTC	Production tax credit
RB-5	Central Valley Regional Water Quality Control Board
RECs	Renewable energy credits. Also known as TRCs, or tradable renewable credits, or green tags.
ROC	Reactive organic compound
SCE	Southern California Edison
SMAQMD	Sacramento Metropolitan Air Quality Management District
SMUD	Sacramento Municipal Utility District
SOx	Sulfur oxides
U.S. EPA	United States Environmental Protection Agency
VOCs	Volatile organic compounds
WDR	Waste discharge report
WUD	Western United Dairymen